

# The role of clinical simulation in preparing for a pandemic

C. Shelton<sup>1,2,\*</sup>, T. Huda<sup>1</sup> and A. Lee<sup>3,4</sup>

<sup>1</sup>Wythenshawe Hospital, Manchester University NHS Foundation Trust, Manchester, UK, <sup>2</sup>Lancaster Medical School, Lancaster University, Lancaster, UK, <sup>3</sup>Columbia University Irving Medical Center, New York, NY, USA and <sup>4</sup>Margaret Wood Center for Simulation and Education, New York, NY, USA

\*Corresponding author: [cliff.shelton@nhs.net](mailto:cliff.shelton@nhs.net)

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## Learning objectives

By reading this article, you should be able to:

- Describe the range of simulation-based techniques that may be applied for increasing organisational capacity in response to the coronavirus disease 2019 (COVID-19) pandemic.
- Develop training pertinent to the needs of institutions, patients, and healthcare workers.
- Use strategies for conserving personal protective equipment (PPE) whilst maintaining effective training.

*Cliff Shelton MSc PhD FRCA is a consultant anaesthetist at Wythenshawe Hospital and director of simulation and clinical skills at Lancaster Medical School. During the first wave of the COVID-19 pandemic he was departmental lead for simulation, with responsibilities including staff training and evaluating standard operating procedures and equipment.*

*Tuheen Huda BSc (Med Sci) MRCP FFICM is a specialty trainee in critical care medicine at Wythenshawe Hospital. He has completed a year in medical education as part of his training, and led the delivery of simulation on prone positioning in critical care during the first wave of the pandemic.*

*Allison Lee MD MS is an associate professor and obstetric anaesthesiologist at Columbia University and medical director of the Margaret Wood Center for Simulation and Education. During the first wave of the pandemic, she developed training for donning and doffing of PPE and tracheal intubation, and designed and ran interdisciplinary cardiac arrest simulation training*

## Key points

- Simulation-based educational approaches are crucial strategies for organisational preparation during a pandemic.
- Pandemic-specific training requirements include the proper donning and doffing of personal protective equipment (PPE), and cross-skilling of providers who may be required to work in unfamiliar roles.
- Drills that test the safety of new processes and newly expanded clinical areas may help to identify latent safety threats and strengthen teamwork.
- Pilot testing of novel equipment and technologies may be facilitated, without risking harm to patients or providers.
- Challenges to implementation include rapidly changing circumstances, time pressures, maintaining participants' safety, and the need to conserve supplies of PPE.

## Introduction

The coronavirus disease 2019 (COVID-19) pandemic has created one of the largest global health challenges in modern history, with more than 100 million confirmed cases and 2.2 million deaths worldwide as of January 2021.<sup>1</sup> Healthcare organisations have grappled with the challenges of mitigating risks to staff members and accommodating surges of critically ill patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), whilst attempting to maintain clinical standards.<sup>2</sup> The safety of healthcare professionals

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involved in the provision of anaesthesia and critical care is of particular concern owing to their involvement in aerosol-generating procedures such as airway instrumentation and cardiopulmonary resuscitation. As case numbers increase, difficult decisions are required to determine which, and at what juncture, clinical services should be suspended; and how staff who usually work in suspended services can be otherwise utilised and redeployed as priorities for hospital services shift.

Simulation encompasses an array of techniques that involve the replication of real clinical situations, usually for the purpose of education or assessment.<sup>3</sup> Modes of simulation range from focussed task training, where individuals engage in a hands-on practice of technical procedures such as central venous cannulation, to the reproduction of complex clinical scenarios involving multiple participants and using patient actors (i.e. simulated or standardised patients) and high-fidelity manikins.<sup>3,4</sup> Approaches such as 'walking through' triage and transport pathways, and exploring clinical scenarios stage-by-stage, also fall under the umbrella of simulation; and are crucial for the early development of new clinical protocols. Simulation is an effective mode of team training, with high-quality studies providing evidence of improvements in knowledge, clinical care, and patient safety.<sup>5</sup>

In this article, we describe the lessons learned from the ways in which simulation-based approaches have been used in anaesthesia and critical care as a tool in preparing for the COVID-19 pandemic, and how ongoing training may contribute during this and future crises.

## Principles of developing simulation during a pandemic

Healthcare systems have been presented with enormous challenges during the COVID-19 pandemic. There must be a solid infrastructure of education to train large numbers of staff rapidly in the face of shortages of personal protective equipment (PPE), surges in critical care cases, staff sickness, shifting infection control guidance, and a constantly evolving evidence base.<sup>6</sup> The scale at which training must occur in a pandemic has the potential to exceed the resources of simulation centres, including the availability of trained facilitators. Thoughtful prioritisation of resource allocation is therefore required.

### Faculty

Simulation-based education should be facilitated by trained faculty members with expertise relevant to the scenarios and intended learning outcomes. At the outset of the COVID-19 pandemic, clinical experience of managing the disease was limited. As such, collaboration between clinicians with relevant skills and knowledge, and experienced simulation educators was therefore required to interpret and apply evolving guidelines as evidence emerged.<sup>6,7</sup> Simulation-based education is demanding of both faculty and time, so educators who also have clinical roles must be afforded the time to contribute to training, which may require release from clinical work. Institutions and clinical departments must therefore support simulation-based education by enabling the faculty to attend, which, during a pandemic, may require the appropriate suspension of elective services. Maintaining an up-to-date understanding of a novel disease amongst faculty members is challenging and mechanisms should be put in place to

disseminate relevant information as knowledge and experience progresses.<sup>7,8</sup>

### Scenario design

Content should be developed using best practices for simulation-based education, and this requires the input not only of subject matter experts in anaesthesia, critical care, and infection prevention, but also others including physicians, nurses, respiratory therapists, estates services, and security officers.<sup>7</sup> Learning objectives should consistently address provider safety and teamwork behaviours.

Scenarios do not need to be designed completely from scratch. Facilitators should take advantage of free open access resources (see [online Supplementary materials](#)), which can be adapted rapidly to local needs in order to maximise the efficiency of the educational design process in a time-critical context.

### Briefing and debriefing

Regardless of the purpose or approach used, effective briefing and debriefing are essential for maximising educational value. Facilitators must cultivate a safe learning environment and communicate the purpose of the session (i.e. education, not assessment). Participants, especially those learning unfamiliar skills, may experience high levels of anxiety, compounded by the stressful circumstances of an evolving pandemic. Facilitators should therefore adjust the intensity of the simulation to minimise anxiety, whilst meeting the needs of the learners. Using a 'safe word or phrase', such as 'this is not a simulation', as used by the Center for Medical Simulation, Boston, MA, allows participants to alert others to real concerns, such as the need to withdraw if overwhelmed.<sup>8</sup> Facilitators may also set ground rules such as allowing participants to pause the scenario in order to ask burning questions.

Because of widespread shortages of PPE, the plans for the use of mock or alternative PPE should be clarified beforehand. In the authors' institutions, approaches to this included the use of disposable warm-up jackets donned backwards as mock impermeable gowns, plastic sheets from office supplies crafted to be used as face shields, and the use of fluid-resistant surgical masks with 'FFP3' written on them in place of respirator (filtering facepiece) masks (Fig. 1). Other educators have suggested using cloth face coverings and bandanas to substitute for masks.

The debriefing process allows facilitators to encourage participant reflection and provides an opportunity to address performance and knowledge gaps.<sup>9</sup> However, facilitators must acknowledge current unknowns regarding the constantly evolving evidence base and changes in clinical guidelines. Participants' observations and feedback may lend unexpected insights about guidelines and processes, which are likely to be in a state of development during the early phase when case numbers are increasing rapidly. These learning points should be summarised and reported back to clinical leaders and hospital managers in order to improve real-world practice.<sup>10</sup> Debriefing may also become a forum during which participants may bring up their fears. Facilitators may take the opportunity to encourage supportive group discussion, supply answers in order to help allay anxiety, and invite input from any content experts who may be present.



**Fig 1** Multidisciplinary team drill to rehearse a newly developed institutional protocol for cardiac arrest management in the setting COVID-19. The utilisation of mock PPE (surgical masks instead of respirator masks) assists with identification of technical and human factor challenges without depleting limited supplies.

### Location

Dedicated training centres equipped with simulated clinical spaces and briefing rooms are convenient for scheduling the training of large numbers of attendees, and for undertaking traditional drills and task training. Simulation centres are therefore well suited to hosting training covering the donning and doffing of PPE or cardiac arrest management, as these procedures may be undertaken in a range of clinical locations and the physical environment has little influence on the basic principles involved in undertaking them.

*In situ* simulation provides valuable opportunities to evaluate logistical issues involving the same environment in which care is delivered, can help to identify latent safety threats, and train staff without them having to leave work areas.<sup>5,11</sup> It is particularly beneficial in the context of the COVID-19 pandemic because of the ways in which clinical environments may influence both staff and patients' safety. For example, the potential for viral transmission via droplet contamination of surfaces in the clinical environment can be explored using manikin-based simulation that incorporates the use of fluorescent powder or dye to mimic respiratory secretions, in order to develop strategies to mitigate risks in clinical practice.<sup>12</sup> However, there are some well-documented potential drawbacks of *in situ* simulation, including the risk of distracting caregivers from clinical responsibilities and of simulated medications and fluids becoming mixed with supplies for patients. This technique therefore requires careful preparation and thorough briefing.

The pandemic has raised interest in remote simulations, in which learners participate over web-based platforms, and virtual- and augmented reality simulation technologies.<sup>13,14</sup> These approaches have the advantage of supporting physical distancing in the context of the pandemic, and can potentially be conveniently conducted from participants' homes. Remote learning may help to minimise the impact of limited availability of training facilities by allowing the

participation of larger groups of learners than would be feasible in person and may help avoid the disruption of training.<sup>13</sup> As with face-to-face simulation, debriefing is a critical part of the learning experience, and considerations must be made regarding how best to accomplish this when remote technologies are used.<sup>15</sup>

### Attendees

During the initial stages of a pandemic, when decisions are made to cancel elective surgery, educators should take advantage of the large numbers of staff who may temporarily be available to attend training. Many of these redeployed staff will have cross-skilling needs, as they may be deployed to unconventional COVID-19 critical care areas such as repurposed wards or operating theatre recovery areas. High clinical demands at the peak of a crisis may make the full participation of all staff members in simulation exercises challenging to achieve. However, at a minimum, clinical and peer educators should be targeted as a priority for training, the learning points from which can subsequently be disseminated locally. Buy-in and support for training must occur at the highest levels of hospital leadership to overcome logistical barriers and acquire necessary resources. Communication between education and clinical practice leaders should remain open and fluid, to ensure that what is being taught remains accurate and in line with rapidly changing policies. Learning may be supplemented by the dissemination of infographics, checklists, and educational videos (see [online Supplementary materials](#)).

### Ensuring participants' safety

The safety of staff during simulation is vital. In the context of a high-impact respiratory pathogen, sessions may be conducted concurrently with advice for members of the public to physically distance or remain at home. In the authors' experience, staff are nevertheless often highly motivated to attend and engage with simulation training, as the content is immediately applicable, and the ability to learn how to practice safely helps allay anxiety and develop self-efficacy.<sup>16</sup>

Simulation centres should therefore develop guidelines for screening participants for COVID-19 symptoms, calculate room capacities in advance in order to ensure that there is sufficient room for the training to take place (sample calculator: <https://www.banquettablespro.com/social-distancing-room-space-calculator>), and limit the size of groups to allow appropriate physical distancing. Appropriate PPE (e.g. fluid-resistant surgical masks) should be used by attendees, particularly when physical distancing cannot be maintained because of the requirements of the scenario, and equipment and high-touch surfaces must be frequently sanitised according to regulatory body recommendations (e.g. <https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html>).

If *in situ* simulation is used, additional COVID-19-specific concerns include a heightened risk of contamination of equipment and viral transmission to attendees and faculty. The use of *in situ* simulation should therefore be circumscribed, particularly in areas in which patients with SARS-CoV-2 are receiving care, and should therefore be conducted only with the appropriate staffing and expertise to support its safe conduct.



### COVID-19 Emergency Intubation Checklist: Critically Ill Patients

PPE
Equipment
Plan
In-room
Post-procedure

OUTSIDE ROOM	INSIDE ROOM	POST PROCEDURE
<p><b>Preparation</b></p> <p>Introductions &amp; allocate roles:</p> <ul style="list-style-type: none"> <li>Intubator (team leader)</li> <li>Airway assistant</li> <li>Drugs / inside runner</li> <li>Outside runner</li> </ul> <p>Agree how runners will communicate</p> <p>Monitoring (ECG, BP, SpO2, ETCO2)</p> <p>Ventilator</p> <p>Other procedures (IV access, NG Tube, lines)</p> <p>Induction equipment: <b>see right and overleaf</b></p> <p><b>"Aerosol Generating" PPE: all in-room staff</b></p> <ul style="list-style-type: none"> <li>Pockets empty</li> <li>Hat</li> <li>Wipeable shoes</li> <li>Inner gloves</li> <li>Long sleeve gown</li> <li>Outer Gloves</li> <li>FFP3 mask / PAPR Hood</li> <li>Eyewear</li> <li>Names visible</li> <li>Full check by buddy</li> </ul>	<p><b>Induction Equipment</b></p> <ul style="list-style-type: none"> <li>Circuit set-up as overleaf</li> <li>Facemask</li> <li>Guedel</li> <li>Yankauer (try not to use)</li> <li>1<sup>st</sup> choice laryngoscope</li> <li>Bougie/stylet</li> <li>Lubricated subglottic ETT</li> <li>Syringe &amp; ties</li> <li>Tray for soiled kit</li> <li>Induction agent</li> <li>NMBD</li> <li>Vasopressor</li> <li>Maintenance sedation</li> </ul> <p><b>Rapid availability of 2<sup>nd</sup> choice laryngoscope &amp; plan B/C/D</b></p> <p><b>Final Checks</b></p> <ul style="list-style-type: none"> <li>PPE safe?</li> <li>Equipment ready?</li> <li>Plan A, B, C, D discussed?</li> <li>Everyone happy with plan?</li> </ul>	<p><b>Preparation</b></p> <p>Anticipate challenges, e.g.</p> <ul style="list-style-type: none"> <li>Mallampati</li> <li>C-spine</li> <li>OSA</li> <li>Mouth opening</li> <li>Conscious level</li> <li>Hypoxia</li> </ul> <p>Mark CTM?</p> <p>Check IV Access</p> <p>Connect monitoring/ETCO2</p> <p>Optimise position</p> <p>Optimise haemodynamics</p> <p>Consider room layout</p> <p>Bin for bougie at bedside</p> <p><b>Airway modifications:</b></p> <ul style="list-style-type: none"> <li>Low-flow PreO2 (aim &lt; 10l/min)</li> <li>Avoid open suction if possible</li> <li>Two person, low pressure mask-ventilation only if necessary.</li> <li>Break circuit at angle piece (not mask) to attach to ETT</li> <li>Inflate cuff before ventilating</li> </ul>
		<ul style="list-style-type: none"> <li>Confirm ETT placement with waveform capnography (avoid auscultation)</li> <li>Connect to ventilator (break circuit after HMEF)</li> <li>Optimise ventilation to high PEEP and 6ml/kg IBW</li> <li>Document intubation (separate sheet, outside room)</li> </ul> <p><b>"Doffing" PPE</b></p> <p><b>Inside room:</b></p> <ul style="list-style-type: none"> <li>Gown - lean forward &amp; pull</li> <li>Outer gloves – with gown</li> </ul> <p><b>Outside room:</b></p> <ul style="list-style-type: none"> <li>Eye protection (buddy removes spectacles, if worn)</li> <li>Inner gloves</li> <li>Mask bottom strap then top. FFP3 in bin/ respirator in tray</li> <li>Wash hands</li> </ul> <p><b>Hand hygiene / alcogel inner gloves) between each step</b></p>

**Call for help early – rescuers must apply PPE**

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### Set-up of Circuit, including HME Filter and Inline Suction

**The circuit**

- Note the layout of the above circuit, designed to minimise disconnections: mask, angle piece, in-line suction, catheter mount, HME filter.
- Following intubation, the circuit is broken between the angle piece and the in-line suction. The in-line suction is then attached directly to the ETT.
- To commence mechanical ventilation, break the circuit between the HME filter and the valve, and attach the ventilator circuit to the HME filter.

**Tips**

- Shape / mould the bougie or stylet to the shape of the VL blade
- Ensure runners know the difficult airway equipment
- Call for help early
- Prior to intubation, agree which teams are doing lines etc.

**Drugs List preparation -Ask the intubator what drugs they require**

Fentanyl	undiluted	1–200mcg	2–4ml
Alfentanil	undiluted	1mg	2ml
Midazolam*	undiluted	5mg	5ml
Ketamine	in saline	200mg	20ml
Propofol 1%	undiluted	200mg	20ml
Rocuronium	undiluted	100mg	10ml
Metaraminol	In saline	10mg	20ml
Ephedrine	in saline	30mg	10ml
Atropine	undiluted	600mcg	1ml
Glycopyrrolate	undiluted	600mcg	3ml

\*check concentration

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Fig 2 Institution-specific emergency tracheal intubation checklist which was developed and refined based on experiences from multidisciplinary simulation. CTM, cricothyroid membrane; ETCO<sub>2</sub>, end-tidal carbon dioxide; ETT, endotracheal tube; FFP3, filtering facepiece level 3; HME, heat and moisture exchanger; HMEF, heat and moisture exchanging filter; IBW, ideal body weight; NG nasogastric; OSA, obstructive sleep apnoea; PAPR, powered air purifying respirator.

## Evaluation

Several approaches to evaluation may be used to assess the quality and impact of simulation-based education. These include informal discussion, feedback questionnaires from learners and faculty, and assessments of learner knowledge (e.g. multiple-choice questions), skills (e.g. structured skills assessments), and practice (e.g. scenario-based testing).<sup>3,17</sup>

The workload demands of the initial phase of the pandemic presented a challenge to conducting in-depth educational evaluation, as resources were focussed on meeting the need to rapidly deliver training to large numbers of staff. However, because a number of novel educational approaches were used, evaluation was arguably of even greater importance than in more routine circumstances.

In the authors' institutions, a pragmatic approach to evaluation was adopted in order to avoid excessive workload and enable the rapid refinement of educational practice. This approach is based on a combination of short evaluation questionnaires, group feedback from learners at the end of sessions, and ongoing discussion within the faculty. Given the stressful circumstances of the pandemic, formal testing of knowledge and skills was not undertaken in order to avoid provoking further anxiety amongst learners.<sup>7</sup> Departmental audit was also used as a surrogate approach to assessing the effectiveness of training. Although safety incidents during previously unfamiliar procedures, such as prone positioning, were low, gaps identified in performance have informed the content and focus of subsequent simulation training.

## Educational leadership

The prominent role that simulation-based education has played in many institutions during the COVID-19 pandemic has highlighted the importance of educational leadership in healthcare organisations. Educators are well positioned to identify both system issues and the degree of staff preparation, and can therefore project general training needs.

Well-constructed training with clearly communicated goals may contribute to decreasing providers' sense of helplessness in the face of a novel and potentially deadly disease. In their role of supplying feedback to administrators, education leaders may help to advocate for staff members who otherwise may struggle to be heard and may serve as visible and reliable sources of information with whom colleagues can share questions and concerns.

The establishment of 'simulation lead' roles in anaesthetic and critical care departments has historically not been universally considered essential, but based on the lessons learned during the months since the pandemic began, we suggest that this should now be strongly encouraged.

## Applications of simulation for COVID-19 preparation

### Organisational planning

Modifications to the hospital physical environment are often necessary to aid the segregation of infected patients to limit SARS-CoV-2 transmission. Changes to the clinical workflow may also be indicated to decrease staff exposure to the virus. For example, because aerosol-generating procedures should ideally be performed in a separate room, patients with COVID-19 who require emergency tracheal intubation may

have to be transferred rapidly to other areas of the unit or hospital.<sup>18</sup>

Before implementing organisational changes and new clinical infrastructure, a 'design thinking' approach beginning with tabletop simulations allows key stakeholders to meet and talk through theoretical clinical scenarios, sit with physical blueprints of the relevant units and build a framework for pathways of care.<sup>19,20</sup> After this, mock-up and walk-through exercises, which do not necessarily require the use of a high-fidelity manikin, are critical for orientating planners to the physical spaces and to improving understanding of the current workflow. Such exercises should be less focussed on clinical management and more on mapping out workflows and identifying latent safety threats, which may then guide staffing levels, changes to the physical environment, and inform the ongoing development of unit- and institution-specific protocols. Think-aloud methods are valuable, whereby participants voice questions and concerns brought to mind in real time.<sup>10</sup>

A simple walk-through simulation undertaken at one of the authors' institutions replicated the transport of a patient from the planned COVID-19 surgical ward to the emergency operating theatre, via a service corridor that was previously not used for transferring patients, but was the proposed route for transporting patients with SARS-CoV-2 infection during the first wave of the pandemic. This brief simulation required only a few members of staff and a hospital bed, but was highly valuable in identifying obstructions that needed to be moved and the number of staff required to undertake a safe transfer, before commissioning the route for patient use.

Abrupt changes in workflow and to the physical environment are likely to increase clinicians' stress and cognitive load. Inviting a range of both senior and junior staff members to join in walk-throughs and provide feedback can enhance staff awareness of pending changes, aid planning, and promote the dissemination of information.

### COVID-19-specific protocol development

Existing local guidelines (e.g. on emergency operating theatre use) must be reconciled, to the best extent possible, with national or international COVID-19 best practices for infection prevention and control, such as those found at [www.icmanaestheticscovid-19.org](http://www.icmanaestheticscovid-19.org) in the UK.

Simulation drills are invaluable for informing local protocols. For example, the emergency tracheal intubation checklist in one author's institution, which was based on national guidance, had to be tailored to their own context, based on lessons learned from drills conducted in the clinical workplace (Fig. 2). Protocol development is often an iterative process, with repeated drills identifying new system issues, leading to further revisions.

### Donning and doffing of PPE

At the most basic level, institution-specific protocols regarding the proper use of PPE to prevent SARS-CoV-2 transmission should be developed and situated within a plan for widespread staff training (Fig. 3). Institutional protocols must be tailored to whichever types of equipment are available and approved, and the appropriate levels of PPE required should be clarified based on the risk of SARS-CoV-2 transmission presented by a given procedure and level of patient contact.<sup>18</sup>

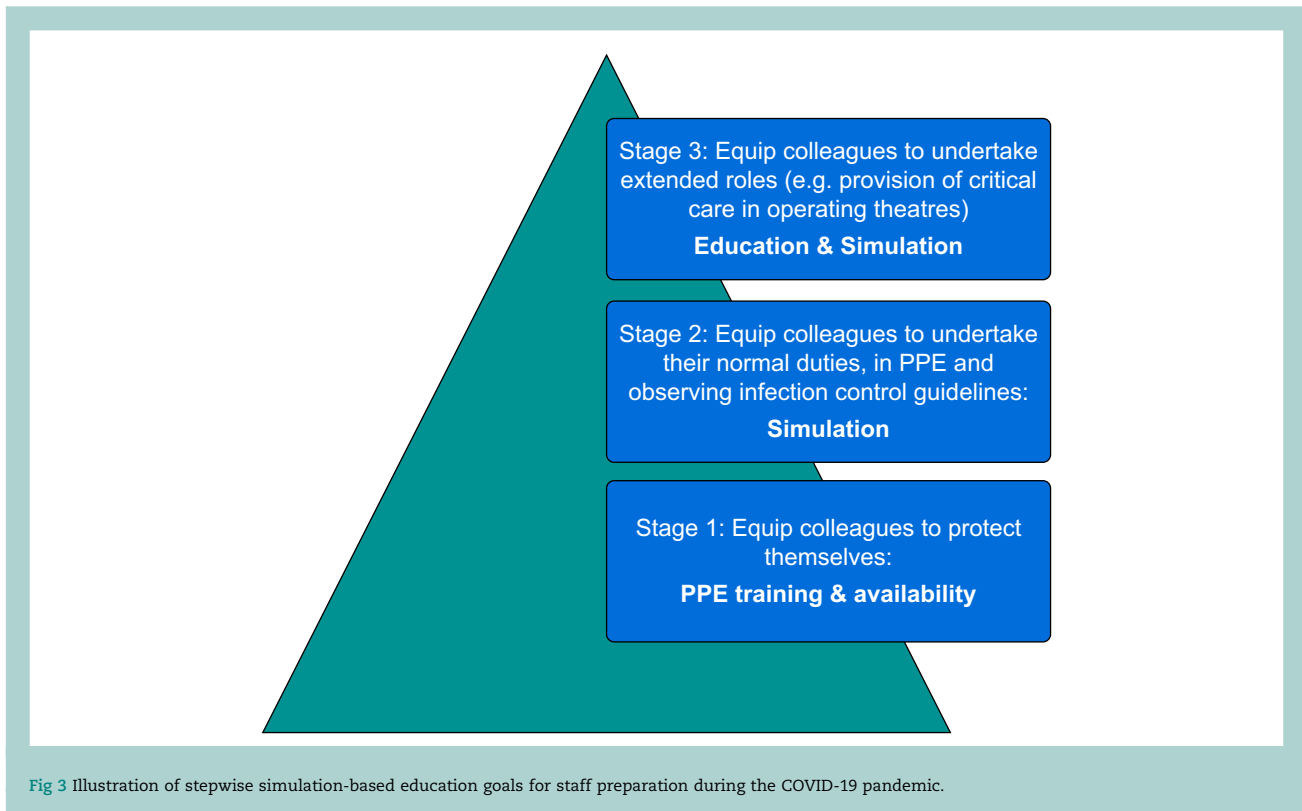


Fig 3 Illustration of stepwise simulation-based education goals for staff preparation during the COVID-19 pandemic.

### Airway management

Healthcare workers involved in the airway management of patients with SARS-CoV-2 infection are considered to be at elevated risk of infection because of the potential for the aerosolisation of respiratory secretions containing the SARS-CoV-2 virus. Simulated practice in rapid sequence induction and tracheal intubation allows providers to rehearse key recommendations such as the careful donning of PPE, despite the potentially urgent clinical situation; limiting the numbers of healthcare staff present during airway management procedures; avoiding bag-mask ventilation if possible; incorporating viral filters in the path of any exhaled gas; using videolaryngoscopy; and using positive pressure ventilation only after inflation of the tracheal tube cuff.<sup>21</sup> Cognitive aids, including checklists, which highlight best practice (e.g. Fig. 2) are useful tools that may be incorporated into the training.

### Cardiopulmonary resuscitation

Cardiac arrest teams must make significant modifications in their behavioural response and management of cardiac arrest in patients with suspected or confirmed SARS-CoV-2 infection, particularly given the daunting statistics that only ~20% of patients who suffer in-hospital cardiac arrest will survive.<sup>22</sup> Apart from the issues described above with respect to airway management, specific considerations include adding the 'bouncer' role to control entry to the room and assess that the proper donning of PPE has been performed, conducting team huddles before room entry, working around the challenges of maintaining effective communication whilst wearing PPE, adding the new roles of personnel who can pass equipment into the room from outside, and emphasising proper doffing of PPE and cleaning

of equipment post-resuscitation. Institution-specific guidelines should be informed and refined by experience gained from simulated cardiac arrest drills.

### Cross-skilling

The rapid expansion in critical care bed requirements creates an urgent need for cross-skilling of healthcare workers including medical, surgical, anaesthetic, and operating theatre staff. Although many redeployed staff are well trained and skilled in their own fields, they are often asked to operate at a less expert level in an unfamiliar context, provoking uncertainty, potentially impacting resilience and risking burnout.<sup>23</sup>

Leadership from critical care departments is essential to identify which skills can be addressed and refreshed through training. Cross-skilling courses commonly include the principles of mechanical ventilation and ventilator management in the critically ill, and the safe prone positioning of critically unwell patients. Developing and encouraging the utilisation of cognitive aids, such as checklists, is extremely valuable for supporting the learning needs of staff asked to take on new roles.

### Technology evaluation

The COVID-19 pandemic sparked a flurry of innovation, attempting to address potential problems such as shortages in ventilators and PPE, and the potential for viral exposure during aerosol-generating procedures. Novel 'homemade' technologies such as intubation boxes, ventilator splitters, and improvised PPE should not be used in clinical practice without appropriate usability testing.<sup>24–26</sup> Simulation offers an





**Fig 4** Usability testing of a novel 'intubation box' for simulated tracheal intubation using a McGrath™ MAC videolaryngoscope (Medtronic, Minneapolis, MN, USA) and a gum-elastic bougie.<sup>15</sup> Reproduced with permission.

opportunity for such innovations to be evaluated before introduction into clinical spaces without risking patient harm.

One example of our experience with usability testing was simulation exploring the use of an intubation box, based on the design by Canelli and colleagues, for tracheal intubation using a McGrath videolaryngoscope (Medtronic, Minneapolis, MN, USA) and a gum-elastic bougie (the first-line equipment for rapid sequence induction in the COVID-19 setting in one author's institution).<sup>27</sup> The simulation exercise rapidly indicated that the intubation box would not be compatible with the airway management techniques used in that institution (Fig. 4).<sup>24</sup> A subsequent simulation-based study concluded that although intubation boxes may reduce exposure to airway secretions, they can reduce the rate of procedural success and damage PPE.<sup>28</sup>

## Conclusions

The COVID-19 pandemic has highlighted ways in which simulation-based techniques may improve organisational readiness and resilience, by meeting the rapid changes in clinical training needs, helping to shape the development of evolving clinical guidelines, and by providing a safe platform for the evaluation of novel technologies. The crisis has placed high demands on simulation education resources, which points to the need for anaesthetic and critical care departments to prioritise the allocation of resources for both equipment and simulation faculty development, as we collectively prepare to navigate an uncertain future.

## Declaration of interests

AL is an editor and editorial board member of *BJA Education*; CS is a former member of the editorial board of *BJA Education*. TH declares no conflicts of interest.

## Supplementary material

Supplementary material to this article can be found online at <https://doi.org/10.1016/j.bjae.2020.12.006>.

## MCQs

The associated MCQs (to support CME/CPD activity) will be accessible at [www.bjaed.org/cme/home](http://www.bjaed.org/cme/home) by subscribers to *BJA Education*.

## References

1. Johns Hopkins University & Medicine. Coronavirus Resource Center. Available from: [coronavirus.jhu.edu](http://coronavirus.jhu.edu) (accessed 30 January 2021).
2. Moghadas SM, Shoukat A, Fitzpatrick MC et al. Projecting hospital utilization during the COVID-19 outbreaks in the United States. *Proc Natl Acad Sci USA* 2020; **117**: 9122–6
3. Dupre J, Naik VN. The role of simulation in high-stakes assessment. *BJA Educ* 2021; **4**. <https://doi.org/10.1016/j.bjae.2020.12.002>
4. Mcgaghie WC, Issenberg SB, Barsuk JH, Wayne DB. A critical review of simulation-based mastery learning with translational outcomes. *Med Educ* 2014; **48**: 375–85
5. Weaver SJ, Dy SM, Rosen MA. Team-training in healthcare: a narrative synthesis of the literature. *BMJ Qual Saf* 2014; **23**: 359–72
6. Li L, Lin M, Wang X, Bao P, Li Y. Preparing and responding to 2019 novel coronavirus with simulation and technology-enhanced learning for healthcare professionals: challenges and opportunities in China. *BMJ Simul Technol Enhanc Learn* 2020; **6**: 196–8
7. Huda T, Greig D, Strang T, Shelton C. Preparation for COVID-19: lessons from simulation. *Clin Teach* 2021; **18**: 87–9. <https://doi.org/10.1111/tct.13262>. Advance Access October 5
8. Mileder L. 'Titrating' simulation training intensity. *Clin Teach* 2019; **16**: 525–6
9. Rudolph JW, Simon R, Raemer DB et al. Debriefing as formative assessment: closing performance gaps in medical education. *Acad Emerg Med* 2008; **15**: 1010–6
10. Brydges R, Campbell DM, Beavers L et al. Lessons learned in preparing for and responding to the early stages of the COVID-19 pandemic: one simulation's program experience adapting to the new normal. *Adv Simul* 2020; **5**: 8
11. Fent G, Blythe J, Farooq O, Purva M. In situ simulation as a tool for patient safety: a systematic review identifying how it is used and its effectiveness. *BMJ Simul Technol Enhanc Learn* 2015; **1**: 103–10
12. Sellens P, Wellbelove Z, Wright D. Testing contamination and cleaning effectiveness in theatre during the COVID-19 pandemic using UV fluorescent powder. *Anaesthesia* 2020; **76**: 136–7
13. Schwartz AM, Wilson JM, Boden SD et al. Managing resident workforce and education during the COVID-19 pandemic. *JB JS Open Access* 2020; **5**: e0045
14. Balmaks R, Auzina L, Gross IT. Remote rapid cycle deliberate practice simulation training during the COVID-19 pandemic. *BMJ Simul Technol Enhanc Learn* 2020. <https://doi.org/10.1136/bmjstel-2020-000671>. Advance Access Jun2
15. Cheng A, Kolbe M, Grant V et al. A practical guide to virtual debriefings: community of inquiry perspective. *Adv Simul* 2020; **5**: 18 (Lond)
16. Brazil V, Lowe B, Ryan L et al. Translational simulation for rapid transformation of health services, using the example of the COVID-19 pandemic preparation. *Adv Simul* 2020; **5**: 9 (Lond)

17. Nicoll P, MacRury S, van Woerden HC, Smyth K. Evaluation of technology-enhanced learning programs for health care professionals: systematic review. *J Med Internet Res* 2018; **20**: e131
18. Department of Health and Social Care, Public Health Wales, Public Health Agency Northern Ireland, Health Protection Scotland and Public Health England. *COVID-19 guidance for infection prevention and control on healthcare settings*. Version 1.0. 2020. Available from: <https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control>. [Accessed 10 January 2020]
19. World Health Organization. *Simulation exercise*. 2020. Available from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/training/simulation-exercise>. [Accessed 20 July 2020]
20. Petrosoniak A, Hicks C, Barratt L et al. Design thinking-informed simulation: an innovative framework to test, evaluate, and modify new clinical infrastructure. *Simul Healthc* 2020; **15**: 205–13
21. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19. *Anaesthesia* 2020; **75**: 785–99
22. Wiberg S, Holmberg MJ, Donnino MW et al. Age-dependent trends in survival after adult in-hospital cardiac arrest. *Resuscitation* 2020; **151**: 189–96
23. Wong AVK, Olusanya O. Burnout and resilience in anaesthesia and intensive care medicine. *BJA Educ* 2017; **17**: 334–40
24. Gould CL, Alexander PDG, Allen CN, McGrath BA, Shelton CL. Protecting staff and patients during airway management in the COVID-19 pandemic: are intubation boxes safe? *Br J Anaesth* 2020; **125**: e292–3
25. Greig PR, Carvalho C, El-Boghdadly K, Ramessur S. Safety testing improvised COVID-19 personal protective equipment based on a modified full-face snorkel mask. *Anaesthesia* 2020; **75**: 970–1
26. Neyman G, Irvin CB. A single ventilator for multiple simulated patients to meet disaster surge. *Acad Emerg Med* 2006; **13**: 1246–9
27. Canelli R, Connor CW, Gonzalez M, Nozari A, Ortega R. Barrier enclosure during endotracheal intubation. *N Engl J Med* 2020; **382**: 1957–8
28. Begley JL, Lavery KE, Nickson CP, Brewster DJ. The aerosol box for intubation in coronavirus disease 2019 patients: an in-situ simulation crossover study. *Anaesthesia* 2020; **75**: 1014–21